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**The Civil Reserve Air Fleet:  
A Vulnerable National Asset**

**By**

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**A paper submitted to the faculty of the Naval War College in partial satisfaction  
of the requirements of the Department of Joint Military Operations.**

**The contents of this paper reflect my own personal views and are not necessarily  
endorsed by the Naval War College or the Department of the Navy.**

**Signature: \_\_\_\_\_**

**13 February 2006**

## **Abstract**

U.S. military war planning is based upon the use of the Civil Reserve Air Fleet (CRAF) to augment organic air mobility assets when deploying and sustaining forces in a contingency. While the CRAF is a tremendous national asset, its resources are not suitable for operations into airfields vulnerable to surface-to-air missile threats or chemical, biological or radiological attack. If a major conventional war erupts and CRAF assets are restricted from operating into planned aerial ports of debarkation, (APODs) a combatant commander's planned force deployment flow will be affected and the deployment timeline will be extended. U.S. military strategic airlift assets will not be sufficient to adequately flow forces to the desired APODs after CRAF transload at an intermediate staging base. The impact will be significant and war plans will have to be reconsidered.

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## INTRODUCTION

One of the key strengths of the United States military is its ability to rapidly project power anywhere in the world on very short notice. The robust air mobility assets of the Department of Defense provide the ability to globally transport vast amounts of cargo and large numbers of passengers in an exceptionally short period of time. No other nation has this ability.

The overwhelming bulk of the air mobility resources of the United States Department of Defense (DoD) lie within the U.S. Air Force's Air Mobility Command, Headquartered at Scott Air Force Base in Illinois. Air Mobility Command (AMC) is the air component of the United States Transportation Command (USTRANSCOM), charged with the synchronized transportation, distribution and sustainment of forces and supplies worldwide.<sup>1</sup> Even with the vast U.S. Air Force air mobility resources available, military airlift demand routinely exceeds supply. When factoring air mobility assets into war planning, it is quickly apparent that there are not enough military aircraft to move the required personnel and equipment to the war zone as quickly as required. In order to meet war planners' timeline requirements, augmentation of organic military assets is required. ("Organic" is a term used to identify DoD-owned aircraft flown by military crews such as the C-5, C-17, KC-10, etc.) To fill this shortfall, the United States relies upon the Civil Reserve Air Fleet (CRAF) to augment its Air Mobility Command military aircraft when necessary. Composed of aircraft and crews from numerous U.S. airlines, the CRAF provides a reserve of over 1,200 aircraft to AMC (and thus ultimately USTRANSCOM) for use during contingencies or national emergencies.<sup>2</sup>

While CRAF assets are a tremendous resource for U.S. military operations, they are not military aircraft and the crews are not military personnel. Inherently, this limits their

effectiveness in a combat environment. Specifically, CRAF assets can not be expected to operate into airfields that face a hostile threat.

This paper will detail vulnerabilities of the U.S. CRAF program with regard to hostile threats. These vulnerabilities will then be related to the combatant commander and show how CRAF restrictions can have an enormous impact on combat planning and operations.

### **The Civil Reserve Air Fleet (CRAF)**

The Civil Reserve Air Fleet program was established in 1951 when the U.S. Government recognized the national security importance of the airline industry and its ability to augment military airlift resources during wartime.<sup>3</sup> Today, the CRAF program is comprised of 1,233 aircraft from 32 different airlines.<sup>4</sup> The program is voluntary and U.S. airlines are not required to participate. However, by participating, member airlines are offered the opportunity to receive some of the nearly \$2 Billion annual business in U.S. Government air travel.<sup>5</sup> In exchange for this business, member airlines must provide allocated aircraft and aircrews to the Department of Defense within 24-48 hours of request.<sup>6</sup>

CRAF assets are divided into three building block elements called stages. These three stages allow the USTRANSCOM commander to tailor the size of the CRAF force for the contingency at hand.<sup>7</sup> Each stage of the CRAF is activated by the Commander of USTRANSCOM with approval of the Secretary of Defense.<sup>8</sup> Stage I provides 81 aircraft consisting of 48 long range passenger jets and 33 long range cargo jets. Stage II provides 287 total aircraft for missions ranging from domestic passenger and cargo transport on up to global cargo and passenger airlift as well as providing an intercontinental aeromedical evacuation capability. Stage III of the CRAF provides 1,233 aircraft capable of providing a passenger airlift capacity of 197.2 million-passenger-miles per day (MPM/D) as well as

42.51 million-ton-miles per day (MTM/D) of cargo airlift capacity.<sup>9</sup> (See Appendix A for a definition of MPM/D and MTM/D)

During most DoD operations, sufficient contract airlift resources are available voluntarily for DoD charter without having to resort to CRAF activation. The CRAF has only been activated twice in its history. The first time was for Operation(s) DESERT SHIELD/DESERT STORM where Stage I was fully activated and Stage II was partially activated.<sup>10</sup> During this buildup in the Persian Gulf, 67 percent of all troops and 25 percent of all air cargo was moved by CRAF carriers. During the DESERT STORM re-deployment, 85 percent of all troops and 42 percent of all air cargo was flown by CRAF aircraft.<sup>11</sup> Twelve years later during Operation IRAQI FREEDOM, Stage I was activated from 8 February 2003 through 18 June 2003. CRAF aircraft moved 78 percent of deploying troops and 85 percent of re-deploying troops.<sup>12</sup> The incredible impact the CRAF has on air mobility is obvious.

### **CRAF Vulnerabilities**

While the CRAF provides a tremendous airlift capability, it does not come without limitations. CRAF assets are civilian aircraft manned by civilian aircrews that are trained to operate into and out of safe, secure, international airports. CRAF crews are not trained to operate in hostile environments and their aircraft are not designed to counter any hostile threats. This vulnerability is apparent in many ways, but two of the most significant vulnerabilities regarding CRAF aircraft and crews relate to Chemical, Biological or Radiological (CBR) environments and to environments threatened by surface to air missiles, specifically Man-Portable Air Defense (MANPAD) missiles.

Organic military airlift aircraft such as the C-17 and C-5 are designed for combat missions. Besides their unique ability to operate on relatively unimproved surfaces, the

aircraft are designed to counter hostile threats. All AMC organic aircraft are capable of operating in an environment contaminated by a CBR attack. The fliers are outfitted with an aircrew-specific chemical defense ensemble called an Aircrew Eye and Respiratory Protection System. (AERPS)<sup>13</sup> The AERPS gear provides the same protection as traditional military CBR defense equipment used by ground forces, but it is specifically designed for aircrew operations by incorporating such unique features as a chemical defense mask that is compatible with an aircrew helmet and the unique pressurized aircraft environment. The aircraft themselves are also modified slightly to allow secure placement of AERPS-unique cooling-blower equipment which can be powered by the aircraft power supply.

CRAF aircraft have no such AERPS equipment provision and civil crews are not trained in the use of the AERPS gear. As a matter of fact, CRAF crews are not routinely trained in the use of any chemical defense equipment. AMC has procured CBR suits/masks for CRAF crews to use while on the ground at a forward area should a CBR event occur,<sup>14</sup> but CRAF crews are not capable of conducting aircraft operations in a CBR threatened environment.

However likely a CBR attack might be, there can be no argument that the worldwide proliferation of MANPADs is the most significant threat to the CRAF fleet. Indeed, recent history has shown that MANPADs are a grave concern to the entire civil aviation industry, not just CRAF forces. MANPADs are small, hand-carried surface to air missiles capable of bringing down the largest aircraft. Due to their portability, they are virtually un-detectable by intelligence sources. MANPADs can be carried in a suitcase and rapidly deployed. Hence, offensively eliminating this threat is nearly impossible. Based on the approach profile large aircraft fly, a MANPAD operator could conceal himself nearly anywhere within a 6

mile wide corridor, up to 25 miles off of either end of an airport's runways and threaten arriving and departing aircraft.<sup>15</sup> Many military aircraft such as the C-17 and C-5 aircraft are equipped with defensive countermeasures which detect MANPAD missile launches and automatically deploy decoy mechanisms to defeat the missile. Additionally, military aircrews train to fly tactical maneuvers that minimize the threat caused by MANPADs. Commercial aircraft have no such protection and the crews are not tactically trained.

There has been much debate recently about how best to counter the MANPAD threat to commercial aviation.<sup>16</sup> The U.S. Government is funding a research program to explore the feasibility of equipping commercial airliners with defensive systems similar to those in use by the C-5 and C-17.<sup>17</sup> Currently, the unit costs of such systems are well into the millions of dollars and one goal of the U.S. Government's study is to field a civil system with an installation cost of \$1 million per unit.<sup>18</sup> However, this is still an excessive figure given the current financial state of the U.S. airline industry. Additionally, fitting defensive countermeasures units to an airliner causes an increase in aerodynamic drag and weight; which, in turn, increases fuel cost for the aircraft. Other airline incremental cost issues also plague the MANPAD defense effort in the eyes of the airlines and thus make voluntary defensive equipment installation unlikely.<sup>19</sup> Even if the U.S. Government were to pay for the installation costs of MANPAD defenses on only the CRAF fleet and the cost per unit was brought down to the \$1 million goal, the overall cost to the U.S. taxpayer would exceed \$1.2 Billion (currently unfunded) and the installation effort would take years. Therefore, it is unrealistic to expect the CRAF fleet to have any MANPAD defenses in the foreseeable future.

The airline industry is acutely aware of the MANPAD threat. On November 22<sup>nd</sup>, 2003, a DHL Airbus A300 contract flight carrying cargo was struck by an SA-7 MANPAD missile while passing through 8,000 feet, 6 miles from the Baghdad International Airport.<sup>20</sup> The missile set the left wing on fire (see figure 1) and caused the loss of all flight controls.



Photo of DHL Airbus A300 on fire after getting hit by an SA-7 MANPAD on 22 November 2003. (Airbus Industries Photo)<sup>21</sup>

Figure 1

The aircraft landed back at Baghdad International Airport only due to an extraordinary feat of airmanship as the crew had no control of the aircraft other than through the manipulation of the engines. The damage to the airframe was significant. (see figures 2 and 3)



Photo of wing damage after MANPAD attack  
(Airbus Industries Photo)<sup>22</sup>  
Figure 2



Photo of wing damage after MANPAD attack  
(Airbus Industries Photo)<sup>23</sup>  
Figure 3

Additional airline MANPAD attacks include the failed 2002 attempt against an Israeli Arkia Boeing 757 taking off from Mombassa, Kenya.<sup>24</sup> With such a history, the MANPAD threat is an issue of grave concern. Accordingly, in cases where the only way to avoid such a threat is through the use of defensive systems and tactical arrival and departure procedures, current AMC policy clearly states that AMC will "...stop commercial operations until such

time as we feel the threat has lessened.”<sup>25</sup> Even without this AMC Policy, an Institute for Defense Analysis (IDA) study found that CRAF operations would be unlikely if crews were faced with the reality of operating into a hostile environment. The study states that a significant number of the civilian crew members, especially on passenger aircraft, would refuse to report for duty when faced with such a threat.<sup>26</sup>

While the CRAF fleet is a tremendous asset to air mobility operations, it obviously is not capable of operating into all airfields planners would like, under all conditions. The much touted CRAF successes in DESERT SHIELD/STORM and IRAQI FREEDOM are worthy of note. However, it is also important to note that CRAF assets operated with impunity during these campaigns. They flew freely into and out of air bases in Saudi Arabia during DESERT SHIELD/STORM and operated without restriction into Kuwait during IRAQI FREEDOM. Had they been unable to operate directly into the desired APODs, these well-known logistical success stories might have unfolded far differently.

### **War Planning Assumptions**

U.S. Military wartime mobility planning is based upon the assumptions and planning factors set forth in the Mobility Requirements Study, MRS-05.<sup>27</sup> MRS-05 calls for a total cargo airlift capacity requirement of 54.5 MTM/D. Of this, 6.2 MTM/D is designated for short-range, intra-theater airlift. (i.e. C-130) The remaining 48.3 MTM/D is the inter-theater airlift requirement. (48.3 MTM/D is equivalent to the capacity of 244 Boeing 747s flying from Dover Air Force Base, Delaware to Sigonella Naval Air Station, Italy every day. See Appendix B, Figure B1) MRS-05 assumes CRAF assets will be used to move 20.5 MTM/D of this 48.3 MTM/D strategic/inter-theater airlift requirement.<sup>28</sup> (see Figure 4 below)

<b><u>54.5 Total Cargo Requirement</u></b>	
6.2	Intra-theater (all organic, i.e. C-130)
<b><u>48.3 Inter-Theater Cargo Requirement</u></b>	
27.8	Organic
20.5	CRAF

Figure 4. MRS-05 Baseline Cargo Assumptions

As of 1 October 2005, the CRAF capability to move international cargo was 42.51 MTM/D using CRAF Stage III,<sup>29</sup> 207% of the MRS-05 required cargo capacity.

For passenger movement, the MRS-05 study did not specifically state the total passenger movement requirement. Instead, it established a CRAF Stage III capacity requirement of 130 MPM/D. (130 MPM/D is equivalent to 204 Boeing 747s each flying 315 passengers from Dover Air Force Base Delaware to Sigonella Naval Air Station, Italy every day. See Appendix B, Figure B2) A 2003 IDA study believed that the need for passenger capacity under all reasonable MRS-05 conditions was actually less and identified a prudent planning estimate of  $100 \pm 10$  MPM/D.<sup>30</sup> Current CRAF Stage III supply levels provide a 197.2 MPM/D capability, 152% of the MRS-05 stated requirement and 179% of the IDA worst-case estimate. In short, current CRAF passenger and cargo assets exceed MRS-05 requirements by a large margin.

### **Restricted CRAF Operations**

With a surplus of airlift capacity available in the CRAF, an operational planner might rest easy unless they consider the relative frailty of the CRAF fleet. If a CBR or MANPAD threat rendered a desired APOD unusable to the CRAF, alternate transportation options would have to be explored. Intermediate Staging Bases (ISBs) would be needed as CRAF assets brought troops and cargo as close as possible to the fight, while staying out of harm's

way. Then, these same troops and cargo would need to be transloaded onto alternate transportation means in order to reach their final destination, the originally desired APOD.

If the CRAF ISB was close enough to the desired APOD, the logistical planner's problem might not be much of an issue. This is especially true if surface transportation assets had the ability to distribute the troops and cargo the final distance without undue delay. In reality, one could consider the ISBs simply as alternate APODs.

However, when geography or distances make surface transportation options unfeasible, planners will be forced to revert to alternate means. An obvious method would be to use organic military assets in an intra-theater role from the ISBs to the APODs. For example, C-130s, C-5s and C-17s could fly relatively short distances, repetitively, to "ferry" troops and cargo from the ISBs into the more hazardous, desired APODs.

### **Organic Airlift Analysis**

When looking at organic military airlift platforms and their airlift capacity, one must set suitable planning assumptions. Air Force Pamphlet (AFPAM) 10-1403, *Air Mobility Planning Factors*<sup>31</sup> is an unclassified, official publication that will form the basis for all subsequent analysis in this text, except where specifically noted. AFPAM 10-1403 specifically states, "Due to the number of variables involved in every air mobility operation, the planning factors presented are **not** universally applicable. Instead they provide 'order of magnitude' approximations in the context of a generic scenario."<sup>32</sup> MRS-05, which this paper is based on, is a broad, "order of magnitude" study. Therefore AFPAM 10-1403 is the most suitable source of data to support this analysis.

It is important to note that AFPAM 10-1403 lists aircraft available/fleet size figures that are smaller than the total inventory numbers of each aircraft type.<sup>33</sup> Total inventory numbers can not be considered due to the many competing demands on airlift resources, maintenance withholds, etc. Hence, the more restrictive baseline fleet numbers from AFPAM 10-1403 are fairly realistic. However, these numbers are still “order of magnitude” approximations and should not be confused with apportionment figures that may be listed in classified DoD publications.<sup>34</sup>

The following analysis of an ISB-APOD “ferry” operation will be broken into three broad areas. First, excess C-130 intra-theater airlift will be analyzed. **[C-130 Excess Capacity Analysis]** Next, an analysis of military strategic airlift capability to move CRAF allocated cargo will be undertaken. **[Organic Airlift Support of CRAF Allocated Cargo]** Finally, military organic airlift support of CRAF allocated cargo and passengers will be studied. **[Organic Airlift Support of CRAF Allocated Passengers and Cargo]**

### **C-130 Excess Capacity Analysis**

If war planners are forced to use an intra-theater “ferry” operation to move troops and cargo from ISBs to the APODs, it would make sense to see if the traditional intra-theater airlift platform, the C-130, could handle the additional requirement and fill the shortfall. In essence, such an operation would simply be an extension of the traditional intra-theater role and conceivably could offer economy of force benefits as a transload operation is already required at an APOD to move the strategic airlift cargo onto C-130 intra-theater airlifters. The question then becomes one of whether or not the C-130 has additional capacity to airlift not only the 6.2 MTM/D already identified for intra-theater movement, but also a percentage

of the strategic airlift inflow that normally would not transload onto intra-theater airlift if the original APOD were accessible by CRAF assets.

The C-130 is range limited to 1,250 miles<sup>35</sup> when carrying a planned combat load. As such, this range will be considered as the maximum distance of the ISB to the APOD for analysis. To determine C-130 viability for the “ferry” operation, one would need to first compare the intra-theater lift requirement of 6.2 MTM/D (see figure 4) with the capacity of the C-130 fleet. Using the MTM/D calculation formula set forth by AMCPAM 10-1403 (see Appendix A, Figure A1) and incorporating the AFPAM 10-1403 C-130 available fleet size of 354 aircraft, the C-130 fleet is only capable of providing 2.86 MTM/D (see Appendix B, Figure B3) of intra-theater airlift capacity, well below the 6.2 MTM/D required by MRS-05. In fact, even if the entire C-130 fleet of 514 aircraft<sup>36</sup> were used instead of the 354 set forth in AFPAM 10-1403, and each aircraft carried its maximum possible payload on each trip (vs. the AFPAM 10-1403 planning factor payload which considers load planning inefficiencies) the C-130 fleet could only muster an intra-theater capacity of 6.05 MTM/D. (see Appendix B, figure B4) This is still short of the 6.2 MTM/D intra-theater requirement. (514 aircraft available is an entirely unreasonable assumption based on the fact that even under the most dire circumstances, at least some aircraft would be unavailable due to maintenance, etc.) As such, there is no excess C-130 capacity to be used for CRAF “ferry” operations from an ISB to the APOD. If nothing else, this segment of the analysis shows that theater war planners also need to account for an intra-theater airlift shortfall when using MRS-05 guidance.

### **Organic Airlift Support of CRAF Allocated Cargo**

The only other organic airlift assets that could be used for this “ferry” operation from ISBs to APODs would be C-5s, C-17s, KC-10s, and KC-135s. For purposes of this “airlift

critical” analysis, the assumption is made that KC-10s would be used for cargo and passenger movement only and that the combatant commander would be forced to rely upon KC-135s exclusively for air refueling operations. Similarly, KC-135s, will be considered fully engaged in air refueling operations and unavailable for airlift support. In addition, since range is not a limiting factor for these “strategic-range” aircraft, a nominal “ferry” range of 1,500 miles was used in determining MTM/D capacity. This factor was used based on an assumption that 1,500 miles would be well outside the threat ring of hostile forces and also because of the MTM/D productivity increase found during longer range operations. Beyond 1,000 miles, MTM/D capacity is not vastly affected by distance as aircraft block speed (a critical component in determining MTM/D capacity, see Appendix A, Figure A1) remains relatively constant. If a 500 mile “ferry” range were used in the analysis, (i.e. trying to get the ISB as close as possible to the APOD) additional penalties in MTM/D capacity would be noted as slower block speed factors and productivity factors must be used, as delineated in AFPAM 10-1403. For example, C-17 MTM/D capacity decreases 36% at a 500 mile range as compared to a 1,500 mile range due to the smaller percentage of flight time spent at high speed cruise and the inefficiencies of tactical positioning/depositioning legs upon the overall airlift flow. (see Appendix B, Figures B5 and B6) Hence, when speaking strictly in terms of MTM/D, the unit used in MRS-05 planning, capacity is maximized by having an ISB 1,000 miles or more from the APOD. Obviously, a closer ISB would facilitate more frequent round-trips between the ISB and the APOD and provide numerous benefits. However, to keep this analysis as closely linked to the terms defined in MRS-05 in an optimistic manner, every effort was made to realistically maximize MTM/D capacity for the respective fleets.

The first question then is what portion of the strategic airlift fleet (C-5s, C-17s and KC-10s) must be used in order to move the CRAF 20.5 MTM/D (see Figure 4) cargo airlift requirement<sup>37</sup> over the 1,500 mile ferry distance during an ISB-APOD operation. One must also examine what impact the loss of these assets would have on the overall inter-theater airlift flow since these assets were originally intended to help fill the other non-CRAF 27.8 MTM/D (see Figure 4) organic airlift requirement<sup>38</sup>. Analysis shows that if 65% of the C-5 and C-17 fleet along with 100% of the KC-10 fleet were used exclusively for ISB-APOD ferry operations, the entire 20.5 MTM/D CRAF airlift requirement could be moved into the hostile theater (See Appendix B, Figures B7-B10). Such an operation would move all of this originally CRAF-planned cargo, although there would be a force flow delay as a transload operation at the ISB would require additional time. Using a weighted average of the composite C-5, C-17 and KC-10 fleet, the average flight is delayed 6.04 hours by this transload. (see appendix B, figure B11). This figure assumes perfect cargo flow from the arriving CRAF asset directly into the organic Air Force asset and does not take into account additional cargo marshalling time as shipments are broken up, consolidated, etc. In reality, the actual delay would be much longer.

However, further exploration of this transload delay is irrelevant. The case study above only examined military movement of CRAF air cargo from the ISB location. Examining this cargo airlift requirement is relatively simple since MRS-05 clearly defines the CRAF-only 20.5 MTM/D portion of the cargo requirement.

### **Organic Airlift Support of CRAF Allocated Passengers and Cargo**

Passenger movement requirements are not as clearly delineated in MRS-05 and truly are the area where the CRAF substitution must be closely studied. As such, the proper test of

the DoDs ability to successfully negotiate a CRAF transload scenario is to see if the required passenger load can be moved simultaneously with the total air cargo load.

Fortunately, all of the aircraft (C-5, C-17 and KC-10) used in this analysis have the ability to carry passengers and cargo concurrently. AFPAM 10-1403 cargo planning weights were coupled with maximum passenger loads/weights for each aircraft. (One passenger and his personal gear weigh 400 lbs as per AFPAM 10-1403<sup>39</sup>) The additive weight of a maximum passenger load(s) coupled with the stated cargo planning figure(s) is within aircraft payload limits. This optimistic method would require perfect synchronization of cargo and passenger movement. Hence, this benchmark would need to be later refined for the inherent inefficiencies in cargo and passenger loading.

The maximum passenger capacity of each aircraft is listed in Appendix B, Figure B12. It should be noted that the C-5 was not analyzed using passenger loading in the lower cargo compartment. Although the capability for cargo compartment passenger loading did exist early in the history of the C-5, this capability has not been maintained and there are not sufficient provisions to fit the C-5 fleet with hundreds of cargo compartment passenger seats. As such, the C-5 is limited to a troops compartment capacity of 73 passengers per aircraft.

Since the previous cargo-only analysis needed 65% of the C-5 and C-17 fleet as well as 100% of the KC-10 fleet to move the CRAF “ferry” payload, those planning numbers will be carried forward to this section of the analysis.

Using identical planning factors as for the cargo analysis section, the million-passenger-miles per day (MPM/D) calculation was completed. (see Appendix A, Figure A2) Using 65% of the C-5 and C-17 fleet along with 100% of the KC-10 fleet yielded a capacity of 36.53 MPM/D. (see Appendix B, Figures B-13 through B-16) The more conservative

2003 IDA study identified earlier in this text placed the requirement for passenger movement at roughly 100 MPM/D. This is a shortfall of catastrophic proportion to war planners.

Even if one were to make incredible assumptions such as 100% use of the C-5, C-17 and KC-10 fleet (a total of 284 aircraft as stated in AFPAM 10-1403) exclusively for ferry operations and assume perfect productivity of each aircraft (no positioning legs) the best capacity that the organic airlift fleet could offer would be 57.21 MPM/D, (see appendix B, Figures B17 through B19) slightly more than half of the IDA adjusted requirement and well below half of the original MRS-05 guidance. The CRAF fleet offers 488 long range passenger aircraft (with many more seats per aircraft than the C-5, C-17 and KC-10 fleet) so it is not surprising that the CRAF passenger load is difficult to fill. Organic airlift assets are simply not capable of moving the MRS-05 passenger airlift requirement.

Furthermore, recall that the cargo analysis above used 65% of the C-5 and C-17 fleet and 100% of the KC-10 fleet to move *only* the originally CRAF-designated 20.5 MTM/D. How would the remaining 27.8 MTM/D of cargo (see figure 4) be moved with the loss of 65% of the C-5 and C-17 force? The current huge excess in CRAF assets could be mobilized and quite possibly move the bulk of this remaining cargo to the ISB. However, some cargo is unsuitable for transport by CRAF aircraft and must be carried on C-5s or C-17s exclusively. Even if the remaining 35% of the C-5 and C-17 force was suitable to fulfill the CRAF-incompatible cargo requirement, recall that the other 65% of the C-5 and C-17 force (along with the KC-10s) could only provide a capacity of 20.5 MTM/D in the “ferry” operation. There still is a shortfall of 18.43 MTM/D capacity after considering the inter-theater contribution of the remaining 35% of the C-5 and C-17 fleet. (see Appendix B, Figures B20 through B22) In short, even the cargo element of the equation is unworkable.

There simply is no way, on a grand scale, to make an ISB-APOD “ferry” operation realistically fill the void left by a restricted CRAF operation scenario. Even though the “ferry” operation offers more round-trips per aircraft, the logic remains simple; it simply is not possible to have 284 C-5s, C-17s and KC-10s fill the void left by hundreds more CRAF aircraft.

What is the bottom-line impact to the combatant commander? If the “entirely unrealistic” expectation were made that 100% of the organic assets could be dedicated to ISB-APOD “ferry” operations with perfect productivity efficiency, the best a combatant commander could hope to do would be to fly roughly one half of his passenger requirement to the theater on time (as stated above, see Appendix B, Figures B17 through B19) and roughly 69% of the cargo requirement to the theater on time. (see Appendix B, Figures B23 through B26). Since “entirely unrealistic” is not suitable for planning, when looking at the situation critically, a combatant commander must be prepared to fight with well less than half of his planned force and roughly half of his planned equipment (over the same amount of time) if CRAF operations are restricted into planned APODs. This reality would undoubtedly lead to a wholesale revamping of combat plans and result in the development of a new planning strategy altogether.

### **Conclusions and Recommendations**

If CRAF assets are not able to fly into the desired APODs due to hostile threats, a combatant commander must be prepared to face grave circumstances concerning deployment and sustainment timelines. It is obvious that the combatant commander must place securing APODs from hostile threats as a top priority if he is to put any faith in war planning

estimates. Stopping the CRAF airlift flow is akin to striking at the Achilles heel of the U.S. military by all but shutting down its rapid global mobility capability.

If a threat restricts CRAF operations, what options does a combat commander have? Obviously the answer to this is highly dependant upon each unique situation. Surface transportation options must be fully explored. However, surface systems are highly dependant upon geography and incur large time penalties. If there are no ports near the ISBs or APODs, sealift is obviously limited. However, if sealift is viable, troop transports (assets which, in some scenarios, can be defended easily using naval forces) could play an important role for the combatant commander. Even as recently as the Falklands War, the British called civil merchant and passenger ships into service out of necessity.<sup>40</sup> The U.S. military could theoretically do the same in an accommodating scenario.

During DESERT STORM and IRAQI FREEDOM, the tremendous mobility of U.S. ground forces was displayed as huge distances were traversed by large armies in a relatively short period of time. However, just as Saudi Arabia was permissive for CRAF air operations, the terrain of the Arabian Desert was also permissive in allowing such rapid ground movement. In a mountainous or jungle environment, ground mobility might be vastly limited. Again, ground transport might be a solution, but only in an accommodating scenario.

If the air option truly is vital to deployment and sustainment operations, creativity will be necessary. For instance, if a MANPAD threat is the restricting mechanism, CRAF operations exclusively at night might provide some capability. MANPADs are generally optically aimed<sup>41</sup> therefore if a civil airliner can not be seen, it most likely will not be fired upon. However, restricting operations to the nighttime hours only obviously limits capability. One could go on and on detailing possible solutions, but the fact remains that if

the combatant commander can not secure his APODs, ingenuity such as noted above may be the logistical planners' only, desperate hope.

The current commander of USTRANSCOM, General Norton Schwartz, recently stated that the CRAF will play an ever increasing role in military airlift.<sup>42</sup> As funding battles with Congress ensue, General Schwartz noted that the DoDs current fiscal air mobility focus will be on buying new air refueling tankers. This will come at the expense of shutting down the C-17 procurement line. Such a stance, with its subsequent reliance on vulnerable CRAF assets, truly poses a potential nightmare for the combatant commander. For better or worse, the CRAF is a vital element of the United States' air mobility system. No other nation has the ability to project force as rapidly and voraciously as the United States. However, without a permissive environment, this national asset's contribution shrinks to a mere fraction of what it could be. Keeping APODs viable for CRAF operations must be a combatant commander's primary concern.

## Appendix A General Formulas

Figure A1:  
Fleet Capacity, Million Ton Miles Per Day (MTM/D)

Million Ton Miles Per Day (MTM/D) is a standard unit of measurement used to define cargo carrying capacity. One MTM/D is the ability to move 1 ton of cargo 1 million miles in a day or 1 million tons of cargo 1 mile in a day. The following formula is used to derive the figure:

$$\text{MTM/D} = \frac{\text{Number of Aircraft}^a \times \text{Block Speed}^b \times \text{Average Payload}^c \times \text{UTE Rate}^{d*} \times \text{Productivity Factor}^e}{1,000,000}$$

Figure A2:  
Fleet Capacity, Million Passenger Miles Per Day (MPM/D)

Million Passenger Miles Per Day (MPM/D) is a standard unit of measurement used to define passenger carrying capacity. One MPM/D is the ability to move 1 passenger 1 million miles in a day or 1 million passengers 1 mile in a day. The following formula is used to derive the figure:

$$\text{MPM/D} = \frac{\text{Number of Aircraft}^a \times \text{Block Speed}^b \times \text{Number of Passengers}^f \times \text{UTE Rate}^{d*} \times \text{Productivity Factor}^e}{1,000,000}$$

Except as noted specifically in the text or in Appendix B, all planning factors used in computations of the above formulas were drawn directly from AFPAM 10-1403, Tables 3-7.

### Definitions as per AFPAM 10-1403

a = Number of aircraft: The specific number of aircraft apportioned to any peacetime operation, contingency or exercise or the number apportioned in the Joint Strategic Capabilities Plan (JSCP) enclosure 11 for tasked OPLANS.

(continued on next page)

b = Block Speed: True airspeed in knots under zero wind conditions adjusted in relation to length of sortie to compensate for takeoff, climbout, descent, instrument approach, and landing.

c = Average Payload: The sum of the weight of passengers and cargo that an aircraft can carry. Note: Cargo is normally expressed in short tons. (one short ton is 2,000 lbs)

d = UTE Rate: The capability of a fleet of aircraft to generate flying hours in a day, expressed in terms of per Primary Authorized Inventory (PAI). Applies only to long-term, large scale operations such as OPLANs. For small operations involving less than the entire fleet, UTE rates are not normally a factor. *For this paper, “Wartime Surge” UTE rates were used.*

Exception: The UTE (utilization) Rate for the C-5 only has been modified from the rate listed in AFPAM 10-1403. The C-5 has two UTE rates listed in AFPAM 10-1403, Table 6. The two values represent aircraft modified by the C-5 Re-Engine and Reliability Program (RERP) and aircraft not modified by the RERP. (an on-going, multi-year program) An average of the two utilization rates has been used for simplicity reflecting the assumption that some aircraft will have been modified at the time of conflict and some will have not been modified

e = Productivity Factor: Gross measure of an aircraft's expected useful ability to move cargo and passengers to a user, expressed as a percentage. Positioning, deposition, and other non-productive legs all diminish the overall productivity. For example, on a strategic airlift mission involving an outbound and a return leg, the return leg is normally considered nonproductive. The productivity factor, in this case would be 50 percent. However, this assumes cargo has already been positioned at the aircraft's departure point. In most situations, airlift aircraft must fly one or more positioning legs to an onload location. Since productive cargo is usually not moved at this time, these positioning legs reduce the overall productivity factor to a value less than 50 percent.

f = Number of Passengers: The number of passengers that are carried on an aircraft for calculation purposes.

## Appendix B

### Formula Computations

Figure B1:

Boeing 747 Cargo Fleet Capacity with 244 aircraft over 4,000 miles = 48.3 MTM/D

$$\text{MTM/D} = \frac{244 \times 459 \times 98 \times 10 \times .44}{1,000,000}$$

Figure B2:

Boeing 747 Passenger Fleet Capacity with 204 aircraft over 4,000 miles = 130 MPM/D

$$\text{MPM/D} = \frac{204 \times 459 \times 315 \times 10 \times .44}{1,000,000}$$

Figure B3:

C-130 Fleet Capacity (354 aircraft) = 2.86 MTM/D

$$\text{MTM/D} = \frac{354 \times 270 \times 12 \times 6 \times .415}{1,000,000}$$

Figure B4:

C-130 Fleet Capacity (514 aircraft, max payload) = 6.05 MTM/D

$$\text{MTM/D} = \frac{514^a \times 270 \times 17.5^b \times 6 \times .415}{1,000,000}$$

a = 514 aircraft is the total fleet size, not an AFPAM 10-1403 planning factor<sup>43</sup>

b = 17.5 tons is the maximum payload at 1,250 miles for the C-130E, not the AFPAM 10-1403 planning factor<sup>44</sup>

Figure B5:

C-17 Fleet Capacity at 500 miles = 9.81 MTM/D

$$\text{MTM/D} = \frac{136 \quad x \quad 335 \quad x \quad 45 \quad x \quad 14.5 \quad x \quad .33}{1,000,000}$$

Figure B6:

C-17 Fleet Capacity at 1,500 miles = 15.26 MTM/D

$$\text{MTM/D} = \frac{136 \quad x \quad 400 \quad x \quad 45 \quad x \quad 14.5 \quad x \quad .43}{1,000,000}$$

(Comparison of B5 and B6: 9.81 MTM/D is 36% less than 15.26 MTM/D)

Figure B7:

65% C-5 Fleet Capacity at 1,500 miles = 6.9 MTM/D

$$\text{MTM/D} = \frac{61 \quad x \quad 410 \quad x \quad 61.3 \quad x \quad 10 \quad x \quad .45^a}{1,000,000}$$

a = .45 Productivity factor was used vs. AFPAM 10-1403 factor of .43 due to expected efficiencies in “ferry” operations resulting in fewer positioning legs

Figure B8:

65% C-17 Fleet Capacity at 1,500 miles = 10.3 MTM/D

$$\text{MTM/D} = \frac{88 \quad x \quad 400 \quad x \quad 45 \quad x \quad 14.5 \quad x \quad .45^a}{1,000,000}$$

a = .45 Productivity factor was used vs. AFPAM 10-1403 factor of .43 due to expected efficiencies in “ferry” operations resulting in fewer positioning legs

Figure B9:

100% KC-10 Fleet Capacity at 1,500 miles = 3.3 MTM/D

$$\text{MTM/D} = \frac{54 \times 428 \times 32.6 \times 9.8 \times .45^a}{1,000,000}$$

a = .45 Productivity factor was used vs. AFPAM 10-1403 factor of .43 due to expected efficiencies in “ferry” operations resulting in fewer positioning legs

Figure B10:

Total MTM/D capability of 65% C5 (B7) + 65% C-17 (B8) + 100% KC-10 (B9) fleets = 20.5 MTM/D

Figure B11:

Delay factors for transload at ISB

CRAF Delay at ISB = No Delay, this download would have been done in any case if CRAF had not been restricted

(All factors below as per AFPAM 10-1403, Table 5)

C-5 Upload Time	=	4.25 hrs
<u>C-5 Expedited Download time</u>	=	2.00 hrs
Total C-5 Delay	=	6.25 hrs/acft (per sortie)

C-17 Upload Time	=	3.25 hrs
<u>C-17 Expedited Download time</u>	=	1.75 hrs
Total C-17 Delay	=	5.00 hrs/acft (per sortie)

KC-10 Upload Time	=	4.25 hrs
<u>C-5 Expedited Download time</u>	=	3.25 hrs
Total KC-10 Delay	=	7.50 hrs/acft (per sortie)

Weighted Average:

61 C-5s Delayed 6.25 hrs	=	381.25 Total Delay Hours
88 C17s Delayed 5.00 Hours	=	440.00 Total Delay Hours
<u>54 KC-10s Delayed 7.50 Hours</u>	=	<u>405 Total Delay Hours</u>
203 Total Acft		1226.25 Total Delay Hours

Total Delay of 1226.25 hrs ÷ Total Fleet of 203 acft = Average Delay of 6.04 Hours

Figure B12:

Maximum Passenger Capacity of each aircraft as per AFPAM 10-1403, Table 3

C-5 = 73\*

C-17 = 90

KC-10 = 75\*

\*Maximum vs. planning factor passenger load as seating is in a separate area from cargo

Figure B13:

65% C-5 Fleet Capacity at 1,500 miles = 8.22 MPM/D

$$\text{MPM/D} = \frac{61 \times 410 \times 73 \times 10 \times .45^a}{1,000,000}$$

a = .45 Productivity factor was used vs. AFPAM 10-1403 factor of .43 due to expected efficiencies in “ferry” operations resulting in fewer positioning legs

Figure B14:

65% C-17 Fleet Capacity at 1,500 miles = 20.67 MPM/D

$$\text{MPM/D} = \frac{88 \times 400 \times 90 \times 14.5 \times .45^a}{1,000,000}$$

a = .45 Productivity factor was used vs. AFPAM 10-1403 factor of .43 due to expected efficiencies in “ferry” operations resulting in fewer positioning legs

Figure B15:

100% KC-10 Fleet Capacity at 1,500 miles = 7.64 MPM/D

$$\text{MPM/D} = \frac{54 \times 428 \times 75 \times 9.8 \times .45^a}{1,000,000}$$

a = .45 Productivity factor was used vs. AFPAM 10-1403 factor of .43 due to expected efficiencies in “ferry” operations resulting in fewer positioning legs

Figure B16:

Total Organic Passenger Capacity = 36.53 MPM/D

65% C-5 (B13) + 65% C-17 (B14) + 100% KC-10 (B15) = 8.22 + 20.67 + 7.64

Figure B17:

100% C-5 Fleet Capacity at 1,500 miles = 14.07 MPM/D

$$\text{MPM/D} = \frac{94 \quad x \quad 410 \quad x \quad 73 \quad x \quad 10 \quad x \quad .5^a}{1,000,000}$$

a = .5 Productivity factor was used vs. AFPAM 10-1403 factor of .43 to display the unrealistic case of “perfect” productivity where no aircraft ever has to position and all flights are flown from the same ISB to the same APOD over and over

Figure B18:

100% C-17 Fleet Capacity at 1,500 miles = 35.5 MPM/D

$$\text{MPM/D} = \frac{136 \quad x \quad 400 \quad x \quad 90 \quad x \quad 14.5 \quad x \quad .5^a}{1,000,000}$$

a = .5 Productivity factor was used vs. AFPAM 10-1403 factor of .43 to display the unrealistic case of “perfect” productivity where no aircraft ever has to position and all flights are flown from the same ISB to the same APOD over and over

Figure B19:

Total Organic Passenger Capacity = 57.21 MPM/D

100% C-5 (B17) + 100% C-17 (B18) + 100% KC-10 (B15) = 14.07 + 35.5 + 7.64

Figure B20:

35% C-5 Fleet Capacity at 1,500 miles = 3.73 MTM/D

$$\text{MTM/D} = \frac{33 \quad x \quad 410 \quad x \quad 61.3 \quad x \quad 10 \quad x \quad .45^a}{1,000,000}$$

a = .45 Productivity factor was used vs. AFPAM 10-1403 factor of .43 due to expected efficiencies in “ferry” operations resulting in fewer positioning legs

Figure B21:

35% C-17 Fleet Capacity at 1,500 miles = 5.64 MTM/D

$$\text{MTM/D} = \frac{48 \quad x \quad 400 \quad x \quad 45 \quad x \quad 14.5 \quad x \quad .45^a}{1,000,000}$$

a = .45 Productivity factor was used vs. AFPAM 10-1403 factor of .43 due to expected efficiencies in “ferry” operations resulting in fewer positioning legs

Figure B22:

Cargo Carried ISB-APOD by 65% C-5/C-17s + 100% KC-10 Fleet = 20.5 MTM/D (B10)

Cargo Carried Directly to APOD by 35% C-5/C-17 fleet = 9.37 MTM/D (B20+B21)

Total Requirement to theater = 48.3 MTM/D - 20.5 - 9.37 = **(18.43)** MTM/D Shortfall

Figure B23:

100% C-5 Fleet Capacity at 1,500 miles = 11.81 MTM/D

$$\text{MTM/D} = \frac{94 \quad x \quad 410 \quad x \quad 61.3 \quad x \quad 10 \quad x \quad .5^a}{1,000,000}$$

a = .5 Productivity factor was used vs. AFPAM 10-1403 factor of .43 to display the unrealistic case of “perfect” productivity where no aircraft ever has to position and all flights are flown from the same ISB to the same APOD over and over

Figure B24:

100% C-17 Fleet Capacity at 1,500 miles = 17.75 MTM/D

$$\text{MTM/D} = \frac{136 \quad x \quad 400 \quad x \quad 45 \quad x \quad 14.5 \quad x \quad .5^a}{1,000,000}$$

a = .5 Productivity factor was used vs. AFPAM 10-1403 factor of .43 to display the unrealistic case of “perfect” productivity where no aircraft ever has to position and all flights are flown from the same ISB to the same APOD over and over

Figure B25:

100% KC-10 Fleet Capacity at 1,500 miles = 3.69 MTM/D

$$\text{MTM/D} = \frac{54 \times 428 \times 32.6 \times 9.8 \times .5^a}{1,000,000}$$

a = .5 Productivity factor was used vs. AFPAM 10-1403 factor of .43 to display the unrealistic case of “perfect” productivity where no aircraft ever has to position and all flights are flown from the same ISB to the same APOD over and over

Figure B26:

100% C-5s + 100% C-17s + 100% KC-10s intra-theater “ferry”

(B23) + (B24) + (B25) = 33.25 MTM/D

33.25 MTM/D is 69% of 48.3 MTM/D

## Notes

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<sup>3</sup> General Accounting Office, Civil Reserve Air Fleet Can Respond as Planned, but Incentives May Need Revamping, Report to the Chairman, Subcommittee on Military Readiness, Committee on Armed Services, House of Representatives (Washington DC: 2002), 3

<sup>4</sup> Air Mobility Command, DoD Commercial Airlift Division

<sup>5</sup> Institute for Defense Analysis, Sustaining the Civil Reserve Air Fleet (CRAF) Program, (Washington DC: 2003), 1

<sup>6</sup> General Accounting Office, 3

<sup>7</sup> "Civil Reserve Air Fleet Stage I Activation Announced," United States Department of Defense News Release No. 064-03, 8 February 2003, <[http://www.dod.mil/releases/2003/b02082003\\_bt064-03.html](http://www.dod.mil/releases/2003/b02082003_bt064-03.html)> [20 January 2006]

<sup>8</sup> Institute for Defense Analysis, 3

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<sup>10</sup> General Accounting Office, 4

<sup>11</sup> Institute for Defense Analysis, 3

<sup>12</sup> General John W. Handy, United States Air Force, "Statement," U.S. Congress, House, Committee on Armed Services, Subcommittee on Projection Forces, State of the Command, Hearings before the Committee on Armed Services, Subcommittee on Projection Forces, 108<sup>th</sup> Congress, 17 March 2004

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<sup>15</sup> Robert Wall and David Hughes, "Missile Quandary, An SA-7 attack on a DHL jet keeps the attention on the debate over protecting civil aircraft," Aviation Week and Space Technology, Vol. 159 Iss. 22, (1 Dec 2003): 46

<sup>16</sup> "Missile Defenses For Airliners Undergo Initial Testing," Air Safety Week, Vol. 19 Iss. 29, (25 Jul 2005): 1

<sup>17</sup> Michael A. Dornheim, "Cost of Protection," Aviation Week and Space Technology, Vol. 163, Iss. 19, (14 Nov 2005): 42

<sup>18</sup> Ibid.

<sup>19</sup> Air Safety Week, Vol. 19 Iss. 29

<sup>20</sup> Aviation Week and Space Technology, Vol. 159 Iss. 22

<sup>21</sup> Captain Jaques Rosay, "Baghdad A300 Incident Discussion," Briefing, Airbus Industries, Toulouse, France: 28 October 2004

<sup>22</sup> Ibid.

<sup>23</sup> Ibid.

<sup>24</sup> Aviation Week and Space Technology, Vol. 159 Iss. 22

<sup>25</sup> Air Mobility Command, Directorate of Operations, 12

<sup>26</sup> Institute for Defense Analysis, A-34

<sup>27</sup> Institute for Defense Analysis, 15

<sup>28</sup> Institute for Defense Analysis, 16

<sup>29</sup> Air Mobility Command, DoD Commercial Airlift Division

<sup>30</sup> Institute for Defense Analysis, 21

<sup>31</sup> Department of the Air Force, Air Mobility Planning Factors, AFPAM 10-1403 (Washington DC: 2003), 1

<sup>32</sup> Ibid., 3

<sup>33</sup> Ibid., 15

<sup>34</sup> Ibid., 3

<sup>35</sup> Department of the Air Force, "C-130 Hercules," Fact Sheet, (Washington DC: 2005)

<sup>36</sup> Ibid.

<sup>37</sup> Institute for Defense Analysis, 16

<sup>38</sup> Ibid.

<sup>39</sup> Department of the Air Force, Air Mobility Planning Factors, 12

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<sup>40</sup> Ruben O. Moro, The History of the South Atlantic Conflict, The War for the Malvinas, (Praeger 1989), 73.

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<sup>42</sup> Rebecca Christie, “US General Says Airlines Will Pick Up Slack for DOD Cargo,” Wall Street Journal, 8 December 2005

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